

## OPEN REDUCTION AND INTERNAL FIXATION VERSUS EXTERNAL FIXATION AND/OR KIRSCHNER WIRES FOR DISTAL RADIUS FRACTURES. A SYSTEMATIC REVIEW

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### **Abstract**

The aim of this study was to compare open reduction and plate fixation in the treatment of distal radius fractures with percutaneous fixation methods (external fixation and/or K-wires) regarding the outcome, using self-reported questionnaires (PRWE – Patient rated wrist evaluation, DASH – Disabilities of the Arm, Shoulder and Hand) as a primary aim, and grip strength and radiological parameters as a secondary aim.

*Data Source:* We performed a systematic review of available evidence through a search of the electronic Medline PubMed database.

*Study Selection:* Randomized clinical trials were included, as well as nonrandomized retrospective studies if they directly compared percutaneous fixation with ORIF, in the last ten years.

*Data extraction:* Functional (PRWE, DASH), objective (grip strength), as well as radiographic outcomes were extracted and reported.

*Data synthesis:* Ten studies were analysed, a total of 647 distal radius fractures (DRF) were included in the meta-analysis, 140 fractures treated with external fixation, 179 with K-wires (total 319 percutaneous fixation), and 328 fractures treated with ORIF. The meta-analysis showed no statistically significant differences between the results for the DRF treatment with ORIF or percutaneous methods at 3, 6 and 12 months regarding PRWE scores and grip strength, as well as final radiological outcome (volar tilt, radial length, radial tilt, ulnar variance). At 3 and 6 months there was a significant difference in the DASH score favouring open reduction and plate fixation, but at 12 months the meta-analysis showed no significant difference between the two methods compared.

*Conclusions:* The results of this meta-analysis for the operative treatment of distal radius fractures did not clearly demonstrate a relevant advantage of any of the fixation methods.

**Key words:** distal radius fracture, meta-analysis, open reduction and internal fixation, external fixation.

### **Introduction**

Many things are subject to trend and fashion, and the treatment of distal radius fractures (DRF) is no exception. Pins and plaster gave way to external fixation, and now internal fixation has begun to supplant all other treatment modalities [1]. Though common, DRF should not be considered as minor injuries since they can result in permanent impairment and pain.

Handoll's Cochrane review of 48 randomized trials concluded that there is not enough evidence for most of the decisions necessary in the management of DRF. It is unclear whether surgical intervention of most fracture types will produce consistently better long-term outcomes. But it is clear that unsatisfactory outcomes can occur after both surgical and conservative treatment. When comparing open reduction and internal fixation with external fixation the

evidence was inadequate to determine whether one method was superior to the other [2].

The American Academy of Orthopaedic Surgeons clinical practice guideline from 2010, based on a systematic review of the published studies, was unable to recommend for or against any one specific surgical method for fixation of DRF. Their summary of the existing evidence was "inconclusive" [3].

Chen and Jupiter suggested that application of a volar plate with angular stable fixation has been used successfully in a number of cohort studies but needs to be examined in stringent trials to determine if there is any benefit when compared with other treatment modalities. There is a need for well-designed clinical, biomechanical, and cost-benefit studies to compare locking plate systems with other treatments [1]. Ultimately, the current enthusiasm for volar fixed-angle plates should be tempered until outcomes and advantages are securely validated by hard science.

Regardless of the device used, anatomical restoration of the anatomy should be the goal for those treating these fractures. Most surgeons are not willing to accept more than 2mm of articular incongruity, a more than 10 degree dorsal angulation or radial shortening of more than 3mm [4].

The aim of this study was to compare open reduction and plate fixation in the treatment of distal radius fractures with percutaneous fixation methods (external fixation and/or K-wires) regarding outcome, using self-reported questionnaires (PRWE, DASH) as a primary aim, as well as grip strength and radiological parameters as a secondary aim.

## **Materials and methods**

### ***Search strategy, study selection, eligibility criteria***

We performed a systematic review of available evidence through a search of the electronic Medline PubMed database. The search started with the following term: distal radius fractures, that identified 4597 studies. Inclusion criteria were: English language studies, clinical trials, plate fixation. Exclusion criteria included studies that were not performed on humans, older than 10 years, and case reports and reviews were also excluded. Then the search was

narrowed to the studies that compared two methods of DRF treatment: percutaneous (K-wires or external fixation) and open reduction and fixation with plates (ORIF). Only those with full text available were considered. Randomized clinical trials were included, as well as non-randomized retrospective studies if they directly compared percutaneous fixation with ORIF.

### ***Types of outcome measures***

As a primary outcome measures the patients' self-reported questionnaires were considered (PRWE – Patient rated wrist evaluation; DASH – Disabilities of the Arm, Shoulder and Hand). Other outcome measures such as radiographic parameters, objective outcomes (grip and pinch strength and range of motion) and clinical outcomes (Gartland and Werley, Green and O'Brian) were reviewed.

### ***Data extraction***

All data from the studies that were deemed relevant were extracted, including level of evidence, sample size, age, multicentricity, fracture type, sex, dominant side, injury energy, operative method, postoperative protocol, length of follow-up, outcome measures, statistics used, results and conclusions.

The results for the DASH scores were reviewed from the selected studies for the 3, 6 and 12 months after surgery and used for meta-analysis as mean values and standard deviation. Only the results for the total PRWE score at 3, 4 and 12 months were pooled for further meta-analysis. The grip strength values were included if they were reported as a percentage of the strength compared with the uninjured side (100%). As such, a larger percentage represented a better outcome. Radiographic parameters that were reviewed were radial tilt and volar tilt (expressed as degrees) and radial length and ulnar variance (expressed in millimetres). The analyses were done by pooling the absolute values for these parameters reported in the selected studies.

Reported means and standard deviations were extracted. For the studies that did not report the outcomes in terms of means and standard deviations we contacted the authors, or derived them indirectly from maximum and minimum values using the formula: range divided by 4, or from the confidence intervals and p-values [5].

### Data analysis

Descriptive statistics were calculated for each study and parameter. Data were reported as mean  $\pm$  standard deviation. For all analyses,  $p < 0.05$  was considered statistically significant.

MetaEasy Software for Microsoft Excel was used for statistical meta-analysis. For the meta-analysis of continuous variables, the weighted mean difference (WMD) with 95% confidence interval (CI) was used. For dichotomous variables, the relative treatment effect was expressed as mean effect with 95% CI. Statistical heterogeneity was investigated using the Cochrane's Q and reported as  $I^2$  statistic.

### Results

#### Literature search

Out of 4597 studies for the DRF, 66 met the inclusion criteria, and of them only 13 were studies that compared two methods of DRF treatment: percutaneous fixation (K-wires or external fixation) and open reduction and fixation with plates (ORIF). For one of them the

full text was not available. The final number of 12 relevant studies was determined (Figure 1). Eleven were controlled randomized trials (Level of evidence I–II) [6–16] and one was a non-randomized retrospective comparative study [17]. When analysing whether the relevant outcome measures were used in these selected studies, one study was excluded for not reporting the selected primary or secondary outcome measures [6]. Another study was excluded [11] because the results were published only as p-values, and the mean and/or standard deviation values were not obtainable. For two of the studies we contacted the authors for additional data for our meta-analysis [12, 13].

The total of 647 distal radius fractures were included in the meta-analysis with 140 fractures treated with external fixation, 179 treated with percutaneous pinning with K-wires (total 319 percutaneous minimally invasive fixation), and 328 fractures treated with ORIF (with conventional plates or locking plates). Summarized data are shown in Table 1.

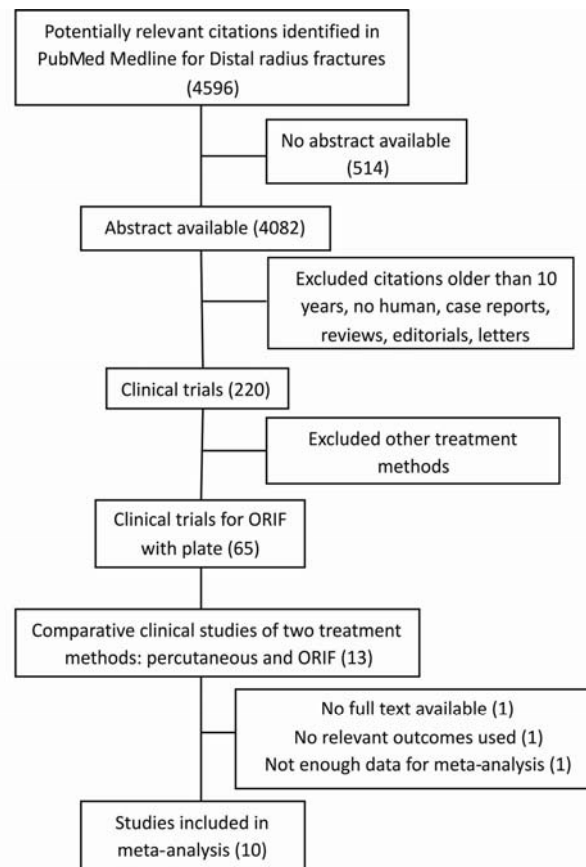


Figure 1 – Study flow-diagram of search process and study identification

Table 1

<i>Summarized data in the systematic review</i>	
Summarized data from analysed studies	n
No. of studies	10
Total No. of fractures	647
No. of minimally invasive	319
External fixation	140
K-wires	179
No. of ORIF	328
Male patients	152
Female patients	495
Length of follow up (months)	15 ± 6.481
No. of fractures with radiologic follow up	576
No. of fractures with patient-rated follow up	617
DASH	542
PRWE	259
Other	228
No. of fractures with clinical follow-up	105
No. of fractures with objective follow-up	473
ROM	398
Grip strength	473
Pinch strength	90

### ***Description of the included studies***

Characteristics and data of the included trials are presented in Tables 2, 3, 4. Table 4 summarizes the outcome measures that are reported in the selected studies.

Table 2

<i>Characteristics of included studies</i>												
Author	No	Year	Study design	Evid level	Centri-city	Methods compared			Type of ORIF			Fracture type
						EF	Pins	Plate (ORIF)	volar	dors rad.	AO	
						conv	lock					
Wei	2	2009	RCT	I	single	x		x	x	x		A3, C
Rozental	3	2009	RCT	I	two		x	x	x			A2, A3, C1, C2
Xu	4	2009	RCT	II	multi	x		x	3.5 mm			C2, C3
Marcheix	5	2010	RCT	I-II	single		x	x	x			A2, A3, C2, C3
Hull	7	2011	Retro		multi		x	x	x			A, C
Grewal	8	2011	RCT	I	multi	x		x	2.4 mm	π		A2, A3, C1, C2, C3
Judy	9	2012	RCT	I		x		x	x			C2, C3
Wilcke	10	2011	RCT		single	x		x	x			A2, A3, C1
Hollevoet	11	2011	RCT		single		x	x	2.4 mm			dors. displ.
Karantana	12	2013	RCT	I	single	x	x	x	DVR			A3, C2, C3

RCT – Randomized controlled trial; EF – external fixation; Pins – percutaneous; K-wires; ORIF – open reduction internal fixation; conv – conventional plates; lock – locking plates; dors. – dorsal; rad. – radial

Table 3

<i>Demographic characteristics of included studies</i>														
Author	Age		Number of patients				Sex			Side		Energy		
	Mean age	Range age	Total	EF	Pins	Plate	M	F	R	L	Domi-nant	Nondomi-nant	low	high
Wei	58	> 18	46	22		24	13	33	41	5				
Rozental	51	19–79	44		21	23	11	33	38	6				
Xu		21–56	30	14		16	18	12	13	17			18	12
Marcheix	73pin, 75pl	> 50	103		53	50	17	86	54	49				
Hull	64pin, 58pl	18–86	71		35	36	16	55			32	39	41	30
Grewal	54ex, 58pl	18–75	50	24		26	12	38			17	32	15	35
Judy	65ef, 65pl	40–80	75	39		36	18	57			31	44		
Wilcke	56ef, 55pl	20–70	63	30		33	15	48			29	34		
Hollevoet	66pin, 67pl	> 50	40		20	20	4	36			15	25	40	
Karantana	51ef, 48pl	18–73	125	11	50	64	28	97	121				82	48

pl – plate, pin/pins (percutaneous K-wires)

Table 4

*Outcome measures used in included studies*

Author	Outcomes									Follow up		
	Patient self-reported			Clinical			Objective			Radiol.	intervals	total m
	DASH	PRWE	Other	GW	GOB	ROM	Grip	Pinch	Other			
Wei	x					x	x	x		x	2w, 6w, 3m, 6m, 12m	12
Rozenal	x					x	x	x	x	x	1w, 6w, 9w, 12w, 12m	12
Xu				x		x	x			x	3m, 6m, 12m, 24m	24
Marcheix	x		x							x	6w, 12w, 26w	6
Hull	x	x									1y, 2y	24
Grewal	x	x				x	x			x	6w, 3m, 6m, 12m	12
Jeudy		x					x			x	3w, 6w, 12w, 24w	24
Wilcke	x	x				x	x			x	10d, 5w, 3m, 6m, 12m	12
Hollevoet	x					x	x			x	3m, 12m	12
Karantana	x		x			x	x			x	6w, 12w, 12m	12

DASH – Disabilities of the Arm, Shoulder and Hand; GW – Gartland and Werley  
PRWE – Patient-rated wrist evaluation; ROM – Range of movements  
GOB – Green and O'Brian

In the study of Wei et al. [7] 46 patients with DRF were included, treated with augmented external fixation (22), a volar locked plate (12) or a radial column locked plate (12). Outcome measures used were the DASH questionnaire, grip and lateral pinch strength, range of motion and radiographic parameter up to 12 months post operation. At three months the mean DASH score was significantly better for patients with volar plate compared to both external fixation and radial plate, but all three groups were comparable later. At six months and one year, the outcomes of all three techniques evaluated were found to be excellent, with minimal differences among them in terms of strength, motion and radiographic alignment.

Rozenal et al. [8] performed a study of 45 DRF, 22 randomized to closed reduction and pin fixation (CRPF), and 23 to open reduction and fixation (ORIF) with volar locked plate. Outcomes were measured with range of motion, grip and pinch strength, radiographs, DASH, time off work and satisfaction rate. Differences between groups were pronounced at six weeks but decreased over time. By one year the average DASH scores were similar in the two groups. All fractures were united six weeks after surgery. This study confirms that volar plate fixation results in less functional disability in the first 12 weeks after treatment than does percutaneous pin fixation. But at one year after injury, it did not identify a difference between groups with regard to functional or radiographic outcomes.

Xu et al. [9] compared the outcomes of external fixation (EF) with open reduction internal fixation (ORIF) with volar 3.5 T-plate. 30 intra-articular DRF were analysed in 24 months intervals with the use of Gartland and Werley; and Green and O'Brien scoring, Knirk and Jupiter grading, range of motion and grip strength. This study found that the clinical and functional outcomes for the two groups were not significantly different.

Marcheix et al. [10] compared 103 dorsally displaced DRF randomized in two groups: mixed pins (percutaneous pin fixation) and volar locking plate fixation. Using the radiological and clinical outcomes (Herzberg scoring and DASH) 26 weeks after surgery, this study concludes that postoperative palmar tilt was significantly better in those stabilized with pins, but loss of reduction was statistically less in those stabilized with a plate. At 26 weeks, results assessed by DASH and Herzberg scores were better in those fixed with a plate.

Hull et al. [17] conducted a retrospective comparative study of 71 patients with dorsally displaced DRF treated with either a volar locking plate (36) or closed K-wire fixation (35). There was no difference in terms of outcome measures for all patients using PRWE scores or DASH scores. A subgroup analysis separating extra-articular and intra-articular fractures also failed to demonstrate a difference in their outcome as measured by PRWE or DASH. Patients having K-wire fixation did have more X-rays postoperatively, but there was no statisti-

cal difference in the number of complications sustained for each group.

Grewal et al. [12] randomized 53 patients with DRF to ORIF (27) or external fixation (26). Outcomes were measured up to 12 months post surgery and included PRWE, DASH, range of motion, grip strength, and radiographic analysis. The PRWE scores were significantly lower for patients treated with ORIF compared to external fixation at 3 months, but these advantages were observed only in the early postoperative period, and overall scores equalized at one year. A higher mean initial preoperative PRWE score was seen with external fixation indicating a more severe initial injury. The DASH scores did not identify any significant differences between internal and external fixation at any time. At 3.6 and 12 months there were no significant differences between groups with respect to range of motion or grip strength, as well as radiological outcomes (radial length and inclination or volar tilt).

Judy et al. [13] carried out a randomized comparison of the efficiency of external fixation versus ORIF with locking plates in intra-articular impacted DRF. Radiological results showed that there was no significant difference in the restoration of the articular profile, or the correction of the dorsal tilt at any time interval during six months. Green and O'Brian's rating was significantly better in the ORIF group over the 6-month follow-up period. The flexion-extension ranges, although significantly higher in the ORIF group at 6 weeks, were similar at final follow-up. At all time intervals the subjective results (PRWE) were not significantly different.

Wilcke et al. [14] investigated 63 patients treated with either bridging external fixation (30) or volar locked plating (33). At 3 and 6 months the volar plate group had better DASH and PRWE scores, but at 12 months the scores were similar. Objective function (grip strength, ROM) was superior in the volar plate group, but the differences diminished at 12 months. Radial length and volar tilt were retained slightly better in the volar plate group.

Hollevoet et al. [15] conducted a randomized study of 40 low-energy DRF in patients older than 50 years, 20 treated with K-wires, and 20 with volar locked plating. Clinical results and DASH scores were determined three

and 12 months postoperatively. No significant difference in radial inclination, palmar tilt, clinical outcome and DASH score was found between plating and K-wires, but the mean difference in ulnar variance was significantly better with plates.

Karantana et al. [16] conducted a trial of 125 displaced DRF randomized to treatment with either a volar locking plate or a percutaneous fixation (K-wires, external fixation). Outcome assessments were conducted at six weeks, twelve weeks, and one year, on the basis of scores on the Patient Evaluation Measure (PEM) and QuickDASH questionnaire, wrist range of motion, grip strength, and radiographic parameters. Use of a volar locking plate resulted in a faster early postoperative recovery of function compared with that following closed reduction and percutaneous wire fixation. However, there was no significant difference at or after twelve weeks. Use of the volar locking plate achieved better anatomical reduction and measured grip strength, but this did not translate to a significant difference in function at twelve weeks or one year (DASH).

#### ***Meta-analysis of the outcome measures reported in the studies***

Patients' self-reported outcome analysis (PRWE and DASH):

The meta-analysis showed no statistically significant differences between the results for the DRF treatment with ORIF and percutaneous methods at 3 months (Mean difference -3.03; 95%CI: -3.40 – -2.66;  $p = 0.000$ ;  $I^2 = 99.15\%$ ), 6 months (Mean difference -1.87; 95%CI: -2.231 – -1.51;  $p = 0.000$ ;  $I^2 = 98.38\%$ ) and 12 months (Mean difference -0.61; 95%CI: -0.0 – -0.32;  $p = 0.0001$ ;  $I^2 = 88.8\%$ ) (Table 5), and no method is favoured at any interval time.

At 3 months after treatment, there was a significant difference in the DASH score favouring open reduction and plate fixation (Mean difference -0.66; 95%CI: -0.85 – -0.47;  $p = 0.0002$ ;  $I^2 = 79.64\%$ ), as well as at 6 months (Mean difference -0.64; 95%CI: -0.9 – -0.37;  $p = 0.9861$ ;  $I^2 = 0\%$ ), but at 12 months the meta-analysis showed no significant difference between the two methods compared (Mean difference -0.36; 95%CI: -0.54 – -0.17;  $p = 0.0123$ ;  $I^2 = 63.16\%$ ) (Fig. 2).

Table 5

Comparison of internal fixation of distal radius fractures (ORIF) and percutaneous fixation methods (EF/pins) shows with DASH, PRWE, grips strength and radiological results as outcome measures

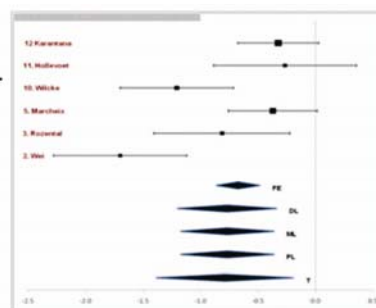
Outcome measure	Time	Studies	No. Fractures		MD	95%CI	p value	Favored
			EF/pins	ORIF				
DASH	3m	6	208	214	-0.66	[-0.85, -0.47]	0.000	ORIF
	6m	3	105	107	-0.64	[-0.91, -0.37]	0.986	ORIF
	12m	7	214	226	-0.36	[-0.54, -0.17]	0.012	no method
PRWE	3m	3	93	95	-3.03	[-3.40, -2.66]	0.0000	no method
	6m	3	93	95	-1.87	[-2.23, -1.51]	0.0000	no method
	12m	3	89	95	-0.61	[-0.90, -0.32]	0.0001	no method
Grip strength	3m	5	157	167	2.32	[2.11, 2.54]	0.000	no method
	6m	4	90	99	2.43	[2.14, 2.72]	0.000	no method
	12m	6	173	181	0.83	[0.62, 1.04]	0.000	no method
Final radiological results	Volar tilt	7	211	222	0.26	[0.07, 0.44]	0.000	no method
	Radial length	4	118	127	0.21	[-0.04, 0.46]	0.0103	no method
	Radial tilt	6	181	189	0.14	[-0.06, 0.34]	0.0001	no method
	Ulnar variance	3	85	86	-0.72	[-1.02, -0.42]	0.0001	no method

95% CI – 95% confidence interval; DASH – Disability of the arm, shoulder and hand; PRWE – Patient-rated wrist evaluation; MD – Mean difference

DASH 3m

Study	Mean	SD	Total	No. Fractures			Mean difference	
				EF/pins	ORIF	Total	MD	95% CI
2. Wei	7	5	24	29	18	22	-1.70	[-2.23, -1.12]
3. Rozental	11	13	23	26	23	21	-0.81	[-1.40, -0.22]
5. Marcheix	25	21	50	33	22	53	-0.37	[-0.76, 0.01]
10. Wilcke	9	8.79	33	27	19.6	30	-1.21	[-1.70, -0.71]
11. Hollevoet	21	21	20	27	24	21	-0.27	[-0.89, 0.35]
12. Karantana	21	17	64	27	20	61	-0.32	[-0.67, 0.03]
<b>Total (95% CI)</b>			<b>214</b>			<b>208</b>	<b>-0.66</b>	<b>[-0.85, -0.47]</b>

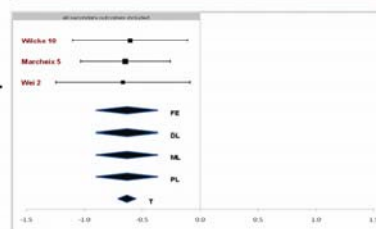
Heterogeneity: Tau<sup>2</sup>=0.233; df= 5; p=0.0002; I<sup>2</sup>=79,64%



DASH 6m

Study	ORIF			PERCUTANEOUS			Mean difference	
	Mean	SD	Total	Mean	SD	Total	MD	95% CI
2. Wei	6	4	24	11	10	22	-0.67	[-1.25, -0.09]
5. Marcheix	10	14	50	22	22	53	-0.65	[-1.03, -0.26]
10. Wilcke	6	8.79	33	14	16.8	30	-0.61	[-1.10, -0.11]
<b>Total (95% CI)</b>			<b>107</b>			<b>105</b>	<b>-0.64</b>	<b>[-0.91, -0.37]</b>

Heterogeneity: Tau<sup>2</sup>=0.000; df= 2; p=0.986; I<sup>2</sup>=0%



DASH 12m

Study	Mean	SD	Total	No. Fractures			Mean difference	
				EF/pins	ORIF	Total	MD	95% CI
2. Wei	4	5	24	18	14	22	-1.36	[-1.93, -0.78]
3. Rozental	4	8	23	9	18	21	-0.36	[-0.96, -0.23]
7. Hull	19	14.3	36	25.3	11.2	35	-0.49	[-0.95, -0.02]
8. Grewal	9.1	9.6	26	8.4	11.2	24	0.07	[-0.49, 0.62]
10. Wilcke	7	8.79	33	11	14	30	-0.35	[-0.84, -0.15]
11. Hollevoet	14	16	20	13	20	21	-0.05	[-0.56, 0.67]
12. Karantana	9	12	64	12	15	61	-0.22	[-0.57, 0.13]
<b>Total (95% CI)</b>			<b>226</b>			<b>214</b>	<b>-0.36</b>	<b>[-0.54, -0.17]</b>

Heterogeneity: Tau<sup>2</sup>=0.113; df=6; p=0.012; I<sup>2</sup>=63,16%

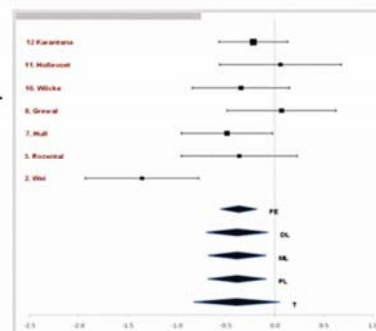


Figure 2 – Forest plot of DASH scores. Pooled treatment effects, represented by the dark diamond T, demonstrate significant difference favouring ORIF on 3 and 6 months follow up. The 12 months pooled effect crosses the midline demonstrating no significant difference

Grip strength meta-analysis:

Grip strength analysis at 3 months (Mean difference 2.32; 95%CI: 2.1 – 2.54; p = 0.000; I<sup>2</sup> = 99.57%), 6 months (Mean difference 2.43; 95%CI: 2.14 – 2.71; p = 0.000; I<sup>2</sup> = 99.62%) and 12 months of follow up (Mean difference 0.83; 95%CI: 0.62 – 1.04; p = 0.000; I<sup>2</sup> = 97.17%) showed no statistically significant differences between ORIF and percutaneous fixation, so no method was favored (Fig. 3).

Radiological parameters meta-analysis:

Meta-analysis showed no method was statistically superior at the final follow-up, regarding the following radiological parameters: volar tilt (Mean difference 0.26; 95% CI: 0.07 - 0.04; p = 0.000; I<sup>2</sup> = 84.05%), radial length (Mean difference 0.21; 95%CI: -0.04 – 0.46; p = 0.01; I<sup>2</sup> = 73.38%), radial inclination (Mean difference 0.14; 95%CI: -0.06 – 0.35; p = 0.0001; I<sup>2</sup> = 80.95%), ulnar variance (Mean difference -0.72; 95%CI: -1.02 – -0.42; p = 0.0001; I<sup>2</sup> = 89.10%) (Table 5).

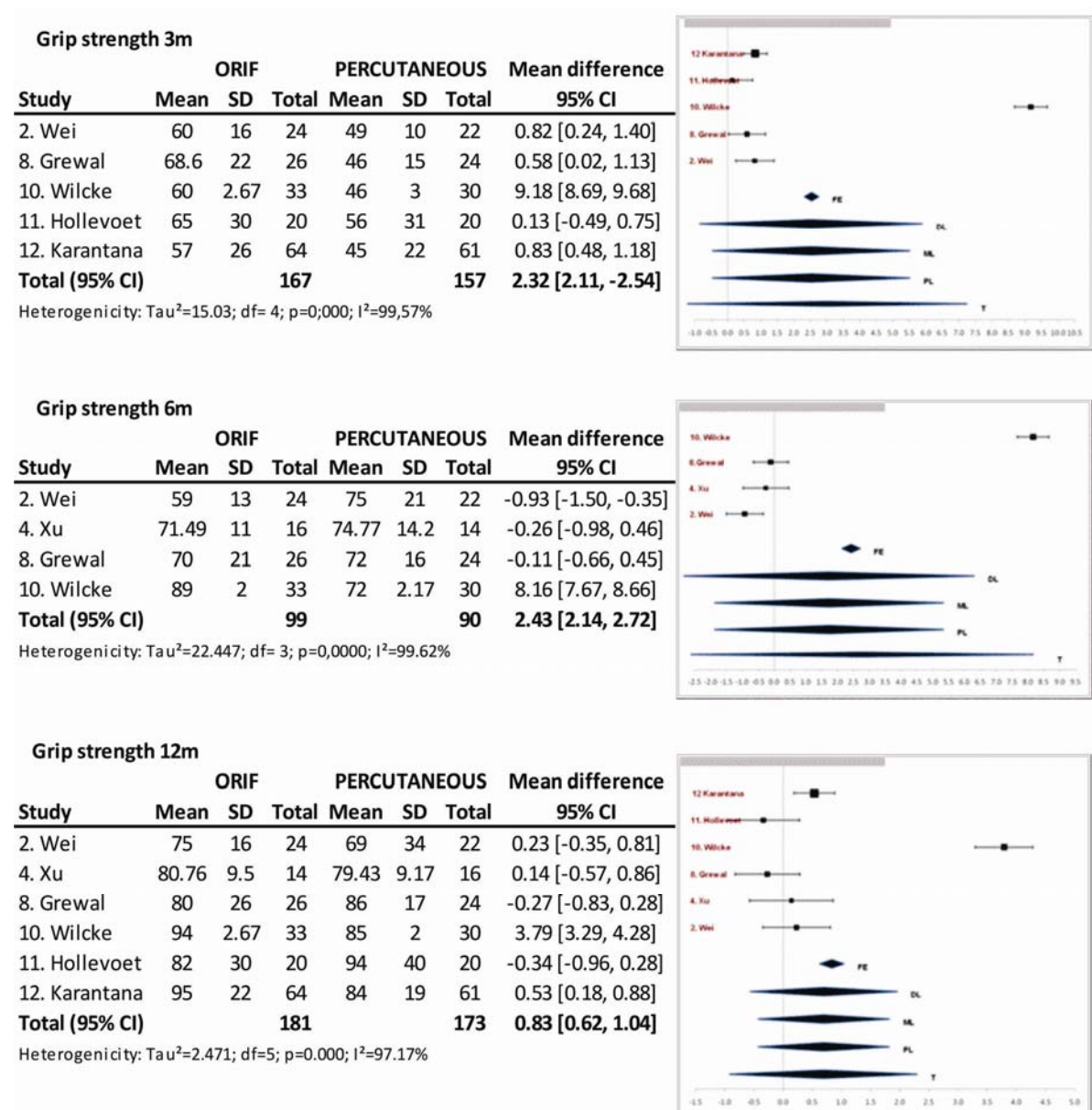


Figure 3 – Grip strength results at 3, 6 and 12 months. Forest plot illustrating grip strength outcome comparing ORIF with percutaneous fixation methods



## Discussion

### Key findings:

1. Regarding the patient-rated outcome, the PRWE score, this meta-analysis favours no method; there were no statistically significant differences in the outcome of the distal radius fractures treated with ORIF or external fixation and/or K-wires.

2. The meta-analysis showed a better patient-rated outcome regarding the DASH scores at 3 and 6 months after surgery for the fractures treated with invasive procedures (open reduction and internal fixation) compared to the fractures treated with minimally invasive procedures (external fixation and/or K-wires). On further follow-up, at 12 months, the results of the DASH scores did not differ significantly.

3. This meta-analysis showed that there is no statistically significant difference in the objective (grip strength) and radiological outcome (volar tilt, radial length, radial tilt, ulnar variance) of the distal radius fractures treated with either ORIF or percutaneous techniques, so no technique is favoured.

Studies that used only objective outcome measures did not analyse the functional needs of the patients, the level of difficulties and their own perception of the disability. That is why in recent years considerable enthusiasm has been expressed for the introduction of new questionnaires as outcome measures that would provide accurate evidence for the disability from the patient's perspective (PRWE, DASH). The patients themselves evaluate their health status and the status of their wrist. MacDermid conducted a comparative analysis for the responsiveness of different questionnaires regarding the evaluation of recovery after a distal radius fracture. His analysis favoured PRWE as the most responsive outcome measure in detecting clinically relevant changes [18].

The results of this meta-analysis regarding the PRWE score as a patients' self-evaluation does not support the use of any of the fixation methods as a favourable method. Both open reduction and plate fixation, as well as percutaneous external fixation and/or K-wire fixation have similar functional outcome evaluated from the patients' perspective. The PRWE meta-analysis was unable to identify a statistically significant difference or a relevant advan-

tage of using open reduction and plates over traditional minimally invasive techniques at all time intervals during a one-year follow up.

Besides the statistical differences, the clinical relevance of the differences of DASH scores should be considered. The minimal clinically important difference in DASH scores for the wrist pathology ranges between 10 and 15 points [19, 20]. Therefore, the outcome at 3 months should be considered both statistically significantly favorable, and clinically better for the patients treated with ORIF compared with percutaneous fixation methods. The outcome at 6 months is statistically significantly favoured for the ORIF group, but the clinically important difference in DASH score was not confirmed.

Considerable heterogeneity was found when analysing the DASH score results from the selected studies at 3 months and 12 months. No methodological issues could be identified explaining this heterogeneity, as the meta-analysis for this outcome measure included only randomized controlled studies for the 3 months analysis, and only one retrospective study, out of a total of 7 studies for the 12 months. After exclusion of this retrospective study the heterogeneity remained similar, so this study was not excluded.

Traditionally, distal radius fractures were treated with bridging external fixation using the concept of ligamentotaxis, usually augmented with K-wires. Many studies reported good to excellent results with this treatment. Gerber et al. outlined the goals of treatment as indirect reduction without further devascularization of bone, aiming at perfect alignment rather than anatomical reduction of extra-articular fractures and optimal rather than maximal internal fixation [21]. The recent advance in locking plate technology was reflected in a rapid expansion in their popularity. In the United States in 1999 trainees approaching board certification treated 58% of DRF with percutaneous pinning, and by 2007 only 19% cases were treated this way [22].

The findings of this meta-analysis favouring ORIF in the early stages regarding the functional recovery evaluated with DASH scores could be supported with the traditional argument that the ORIF (especially locking plates) enables a more rigid construct and thus earlier mobilization and more aggressive physio-

therapy protocols, therefore resulting in less initial weakness and stiffness. This more rapid recovery could be beneficial for high demanding patients (athletes, labour workers).

The results of this meta-analysis for the DASH scores are similar to the findings of the meta-analyses of Wei in 2011 [23], Walenkamp in 2013 [19] and Xie [5] in 2013 for the earlier recovery period, but differ for the 12 months outcomes.

There are certain limitations in this meta-analysis. It was impossible to match the patients' age across the cohorts, so the influence of age could not be detected. The substantial heterogeneity can interfere with the validity of the pooled outcomes. The sample size of the studies we included in the meta-analysis, as well as the number of studies for each outcome, is relatively small, but the quality of the meta-analysis is more affected by the heterogeneity than the number of the studies. In further research, the effects of the different plate fixation techniques should be compared (conventional versus locking) and each of the plate techniques using the percutaneous techniques (external fixation and/or K-wires) in multicentre trials to obtain more robust evidence.

### Conclusion

The current available evidence for the operative treatment of distal radius fractures did not clearly demonstrate a relevant advantage of any of the fixation methods. The meta-analysis of the patients' self-assessment with the PRWE questionnaire showed no statistically significant differences in the outcome of the distal radius fractures treated with ORIF or external fixation and/or K-wires. There was a significant difference between two methods favouring ORIF only in the early stages of the follow-up (3 and 6 months) regarding the patient-rated subjective functional outcome with the DASH questionnaire. However, ORIF and percutaneous fixation methods provided the same functional recovery one year after a distal radius fracture. So the ORIF treatment can be recommended for patients requiring a faster functional recovery after injury. Finally, both treatment methods provided the same recovery of grip strength and enabled equivalent restoration and retention of the radiographic parameters of the fracture.

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## Резиме

### **ОТВОРЕНА РЕПОЗИЦИЈА И ВНАТРЕШНА ФИКСАЦИЈА НАСПРОТИ НАДВОРЕШНА ФИКСАЦИЈА И/ИЛИ КИРШНЕРОВИ ИГЛИ ЗА ФРАКТУРИТЕ НА ДИСТАЛНИОТ РАДИУС. СИСТЕМАТИЗИРАН ПРЕГЛЕД И МЕТААНАЛИЗА**

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Целта на овој труд е да се спореди отворената репозиција и фиксација со плочка (ORIF) во третманот на фрактурите на дисталниот радиус (ФДР) со перкутаните методи на фиксација (надворешна фиксација и/или К-игли) преку исходот изразен со прашалниците за самоevalуација (PRWE – процена на рачниот зглоб од страна на пациентот, DASH – онеспособеност на раката, рамото и шаката) како примарна цел, како и преку силата на стисок и радиолошките параметри како секундарна цел.

*Извор на податоци:* Извршен е систематизиран преглед на достапната литература со пребарување на електронската база на податоци на Medline PubMed.

*Селекција на студии:* Вклучени се рандомизирани клинички студии, како и нерандомизирани ретроспективни студии ако директно споредуваат перкутана фиксација со ORIF од последните десет години.

*Екстракција на податоци:* Резултатите за функционалниот (PRWE, DASH), објективниот (сила на стисок), како и радиографскиот исход се издвоени и презентирани.

*Синтеза на податоци:* Анализирани се 10 студии, вкупно 647 фрактури на дисталниот радиус се вклучени во метаанализата, од кои 140 се третирали со надворешна фиксација, 179 со К-игли (вкупно 319 со перкутана фиксација) и 328 се третирали со ORIF. Метаанализата не покажа статистички значајна разлика на резултатот на третманот на ФДР со ORIF и со перкутаните методи на 3, 6 и 12 месеци од аспект на PRWE бодовите и силата на стисок, како и финалниот радиографски исход (воларен агол, радијална должина, радијален агол и улнарна варијанса). На 3 и 6 месеци постои значајна разлика на DASH бодовите која ја фаворизира отворената репозиција и фиксацијата со плочка, но на 12 месеци метаанализата

не покажа значајна разлика на двата компарирани метода.

*Заклучок:* Резултатите на оваа метаанализа за оперативниот третман на фрактурите на дисталниот радиус не демонстрираат јасно реле-

вантна предност на ниту еден метод за нивна фиксација

**Клучни зборови:** фрактури на дистален радиус, метаанализа, отворена репозиција и внатрешна фиксација, надворешна фиксација.